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Standardization of pre-treatments for drying of ginger cultivars

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Abstract
Preservation of foodstuffs through drying is a very ancient practice. Processing of commercial value spice crops such as ginger command priority in many countries including India as it is considered as a major food ingredient on account of its natural flavour and medicinal properties. This study was undertaken to identity suitable drying conditions by using different artificial drying methods. Drying assays were conducted in Open sun dryer and solar tunnel dryer. Ginger rhizomes were scraped and dried from an initial moisture content of 83.3 % to final moisture content of less than 11-12% by various drying methods such as sun drying and solar tunnel drying. Scraping of ginger rhizomes significantly reduced the drying time of ginger in all the drying methods. It was observed that drying of whole ginger rhizomes under sun took the maximum time (18 days) of *Rio-de-Janeiro* and *Himachal* followed by solar tunnel drying (12 days). Significant reduction in essential oil and oleoresin content of dry ginger was found as the rhizome length decreased. It was observed from the drying studies that whole ginger rhizomes dried faster under solar tunnel drying compared to open sun drying. The drying characteristics are nearly similar for all the methods with a little variation. Drying was continued till the sample attained a constant weight.

Keywords: Ginger drying methods, solar tunnel dryer (STD). open sun dryer (OD)

Introduction

Ginger, (*Zingiber officinale*) Roscoe is one of the most widely used spices of the family Zingiberaceae. Ginger grown in different parts of the country varies considerably in its intrinsic properties and its suitability for processing. The important quality parameters of ginger are its fibre content, volatile oil content and non-volatile ether extract. The size of ginger rhizome is particularly important when it is processed to dried ginger. Some areas grow ginger yielding very large rhizomes, which are marketed as fresh ginger, but unsuitable for converting to the dried spice due to their high moisture content. This causes difficulties in drying and frequently a heavy wrinkled product is obtained and the volatile oil content is often low and below standard requirements.

Drying is a complicated process involving simultaneous heat and mass transfer. The required amount of energy to dry a particular product depends on many factors, such as initial moisture content, final moisture content. Open air and uncontrolled sun drying is still the most common method used to preserve and process agricultural product. But uncontrolled drying suffers from serious problem of dust, infestation by insect, product may be seriously degraded to the extent that sometimes become market valueless and resultant loss and the food quality may have adverse economic effects on domestic and international market. Dryers have been developed and used to dry agricultural products in order to improve shelf life. Because of full scale experimentation of different products and configurations of drying system is very time consuming and costly. In order to improve the quality, the traditional natural sun drying must be replaced by modern drying methods. Drying characteristics of specific products should be determined to improve the quality.

Ginger when used as vegetable is harvested from sixth month onwards while for preparing dry ginger, the produce is harvested after eight months of planting when the leaves of the plant turn yellow and starts drying. The harvested clumps of ginger are cleaned manually to remove the dried roots and soil clods. The clumps are then broken to sufficiently large size rhizomes suitable for preparing dry ginger. After cleaning, the rhizomes are subjected to peeling. Peeling, in case of ginger is definitely an important unit operation where the fully matured rhizomes are scraped with bamboo splits having pointed ends to remove the outer skin before drying to accelerate the drying process. Deep scraping with knives need to be avoided to prevent the damage of oil bearing cells which are present just below the outer skin. Excessive peeling will result in the reduction of essential oil content of the dried produce. The peeled rhizomes are washed before drying. The dry ginger so obtained is valued for its aroma, flavour and pungency (Ogunlade, 2018) [4]. Traditionally, ginger is sun dried in a single layer in open yard to get a brown, irregular wrinkled surface dry ginger which when broken shows a dark brown colour. The quality of dried ginger obtained from different driers was necessary to be evaluated before selecting a suitable method for commercial drying of ginger. Hence the present study was undertaken to study the effect of drying methods on the quality of dry ginger.

Mahesh and Sunil (2018) [6] studied the convective and the evaporative heat transfer coefficients of ginger (*Zingiber officinale*) drying in an indirect solar cabinet dryer under the induced forced convection mode is presented. The average value of constants ‘C’ and ‘n’ were evaluated as 0.999 and 0.318, respectively. The average values of the convective and the evaporative heat transfer coefficients were found to be 3.95 W/m2 °C and 160.47 W/m2 °C respectively, for the given mass samples of ginger. Sarkar *et al*. (2020) [5] observed from the drying studies that whole ginger rhizomes dried under sun drying or in a solar tunnel drier retained the maximum essential oil (13.9 mg/g) and oleoresin content (45.2 mg/g) of dry ginger. In mechanical drying, the drying temperature of 60 °C was considered optimum. However there was about 12.2 % loss in essential oil at this temperature. Thippanna et al. (2019) [8]. A novel product - osmotically dried and appetizing flakes from fresh ginger rhizomes keeping in view its nutritional significance. The commercial adoption of this technology seems to be a profitable venture for efficient utilization of fresh ginger rhizome as well as enhancing the income of growers.

Materials and Methodology

The experiment was conducted at College of Horticultural Engineering and Food Technology Devihosur, Haveri, Karnataka. The two variety Rio-de-Janeiro and Himachal Ginger were purchased from of the farmers and was used in the experiments. The gingers were sorted out manually to remove all the undesirable material. Then the material was washed thoroughly in water to remove the adhering soil and extraneous matter. The cleaned product was then weighed and samples were made for each methods of drying. Initial moisture content of the ginger was determined by oven drying method which was found to be 83.3%.

Drying equipment: Solar energy is used for drying various industrial and agricultural products in open sun and in solar dryer. In hot sunny areas where the solar radiation is abundant, solar drying seems to be the most promising and modest approach for preservation of various agricultural products. In the present study, an attempt was made to compare the drying characteristics of the ginger using different drying method. The ginger was dried using two methods viz.; open sun drying & solar tunnel drying.

Open sun drying

Sun drying is used to denote the exposure of the food material to direct solar radiation and the convective power of the wind. Sheets are mostly used as drying platform. The surface area of the sheet was enough large to spread 2-4kg of ginger. Sheets were completely cleaned and the samples were spread over the sheets uniformly. The loss of moisture was recorded at every 24 hours.Drying was continued till the sample was completely dried (10-14%). The drying time and drying rate depends on the ambient temperature.

Fig 1: Open sun drying

Solar tunnel drying

The experiment was conducted to study the effect of different drying methods on quality of ginger at Horticultural Research and Extension Station, Devihosur, Haveri, Karnataka, India. The solar tunnel dryer is made of UV (200 μ) stabilized polythene film, The temperature andrelative humidity outside and inside the solar tunnel dryer was recorded during the experimentation.

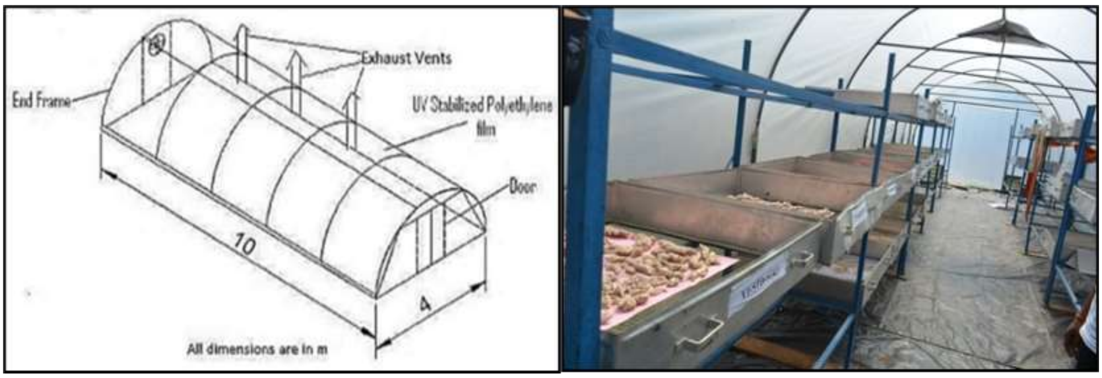

Fig 2: Solar tunnel dryer

Table 1: Treatment details

V1S1	Variety 1 (Rio-de-janeiro) sulphur concentration 120g
V1S2	Variety 1 (Rio-de-janeiro) sulphur concentration 180g
V1S3	Variety 1 (Rio-de-janeiro) sulphur concentration 240g
V2S1	Variety 2 (Himachal) sulphur concentration 120g
V2S2	Variety 2 (Himachal) sulphur concentration 180g
V2S3	Variety 2 (Himachal) sulphur concentration 240g
V1-OD - Control	Variety 1 (Rio-de-janeiro) open sun drying control
V1-STD - Control	Variety 1 (Rio-de-janeiro) solar tunnel dryer control
V2-OD - Control	Variety 2 (Himachal) open sun drying control
V2-STD - Control	Variety 2 (Himachal) solar tunnel dryer control

Chemical Analysis

Oleoresin Content: A Soxhlet extractor is a laboratory apparatus originally designed for the extraction of a lipid from a solid material. Typically, Soxhlet extraction is used when the desired compound has a limited solubility in a solvent, and the impurity is insoluble in that solvent. It allows for unmonitored and unmanaged operation while efficiently recycling a small amount of solvent to dissolve a larger amount of material.

Description: A Soxhlet extractor has three main sections:

1. A percolator (boiler and reflux) which circulates the solvent,
2. A thimble (usually made of thick filter paper) which retains the solid to be extracted, and
3. A siphon mechanism, which periodically empties the thimble.

The solvent is heated to reflux. The solvent vapour travels up a distillation arm, and floods into the chamber housing the thimble of solid. The condenser ensures that any solvent vapour cools and drips back down into the chamber housing the solid material (Ginger rhizome). The chamber containing the solid material (Ginger rhizome) slowly fills with warm solvent. Some of the desired compound dissolves in the warm solvent. When the Soxhlet chamber is almost full, the chamber is emptied by the siphon. The solvent is returned to the distillation flask. The thimble ensures that the rapid motion of the solvent does not transport any solid material to the still pot. This cycle may be allowed to repeat many times, over hours or days.

During each cycle, a portion of the non-volatile compound dissolves in the solvent. After many cycles the desired compound(oleoresin) is concentrated in the distillation flask. The advantage of this system is that instead of many portions of warm solvent being passed through the sample, just one batch of solvent is recycled.

After extraction the solvent is removed, typically by means of a rotary evaporator, yielding the extracted compound. The non-soluble portion of the extracted solid remains in the thimble, and is usually discarded (AOAC Method).

Fig 3: Soxhlet apparatus

Colour attributes

Colour attributes for ginger rhizome were evaluated using a Colorimeter 'L*' (lightness and darkness), 'a*' (redness and greenness) and 'b*' (yellowness and blueness). To start with, the sensor was calibrated with a black and white standard tile to measure the colour.

Fig 4: Colorimeter

Moisture analysis

The analysis of different properties of dried gingers was done to deduce valuable information on mechanism of drying of ginger. Statistical analysis of drying process was made to know the relative effect of various drying conditions on the final moisture content of ginger.

The moisture removing rate was expressed on a wet basis

$$M.C\ (wetbasis) = \frac{Ww-Wd}{Ww} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,
M.C (wet basis) is the initial moisture removing rate (%wet basis),
Ww is the weight of wet ginger (g),
*Wd*is the weight of dry ginger (g).

The oleoresin content was expressed by

$$\text{Oil content} = \frac{Wf-Wi}{Sw} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,*Wf* is the weight of round bottom flask after extraction (g),
Wi is the weight of round bottom flask before extraction (g),
Sw is the sample weight.

Fig 5: Hot air oven

Microbial analysis

The quality of ginger rhizome powdered was based on the number and kind of microorganisms present, which was determined by total plate count (TPC)by IS 5402..(2012) Enumeration of microbes has been done & results are expressed in cfu/ g.

This analysis was carried in order to check the microbial load on ginger. In Total Plate Count (TPC) method, all microorganisms checked by using NA (Nutrient agar) media. First the serial dilution is done by using sterilized water in test tubes i.e. 10ml of sample is dissolved in 90 ml of waterand then serial dilution is done by transferring 1ml from each test tube to subsequent tubes. 1 ml from each dilution is poured into the petri plates and then 15-20ml media is poured in each of the petri dishes and incubated at 30 °C for 24 hours.

After 24 hours of incubation it is observed that mould colonies were grown on passion fruit and kokum blended samples. Formula for calculating Total plate count

$$N = \sum C * 1.1 * D / V$$

N: number of microorganisms, ∑C: sum of colonies, V: volume of inoculation in each dish, D: corresponding dilution.

Statistical analysis: Each experiment was repeated thrice, and results were expressed as mean ± standard error mean (SEM).One-way analysis of variance was done using ANOVA procedures. Significant differences among the means were determined by Post-hoc Tukey's multiple comparison test at the 95% confidence level.

Results and Discussion

In this study, the parameterssuch asdrying rate, moisture analysis, oleoresin content, microbial load and colour in terms of L*, a*, b* were analysed.

Moisture analysis

The drying rate of both varieties in solar tunnel dryer resulted in high moisture loss in 13-14 days to final moisture content of 11-12% as compared to open sun drying. The Fig (a) depicts the initial moisture content of 83.13% to final moisture content of 11.93% in OD and 11.8% in STD for 17-18 days and 13-14 days respectively with sulphur fumigated at concentration of 120g which was done for bleaching effect in ginger. The Fig (b) depicts the initial moisture content of 83.13% to final moisture content of 11.62% in OD and 11.31% in STD for 17-18 days and 13-14 days respectively with sulphur fumigated at concentration of 180g. The Fig (c) depicts the initial moisture content of 83.13% to final moisture content of 11.95% in OD and 11.8% in STD for 17-18 days and 13-14 days respectively with sulphur fumigated at concentration of 240g. The Fig (d) depicts the data of control sample in which sulphur fumigation was not performed, the initial moisture content of control sample was also 83.13% to final moisture content of 12.52% in OD and 12.46% in STD for 18-20 days and 14-15 days respectively. It was observed that drying of whole ginger rhizome under sun took maximum (9 days) followed by solar tunnel dryer (8 days)**,** the similar observations were recorded byJohn Zachariah (2019) [3].

The same data was resulted in variety 2 (Himachal), the STD method resulted in higher moisture loss than OD, The Fig 8: (a)(b)(c)(d) depicts the drying rate of variety 2 in OD and STD of same sulphur concentration as variety 1 with control sample. For 18-20 days and 13-14 days with respect to OD and STD. According to the pooled result the maximum moisture loss is seen STD compared to OD in both the varieties Annu *et al*. (2021) [1].

The oleoresin contains a major pungency and Biting sensation of shogaol and gingerol which has refreshing aroma of ginger. It is a free flowing, homogeneous, dark brown liquid.The oleoresin content was high in the STD as compared to the OD. STD-control depicts highest oleoresin content than OD-control followed by V_1S_3, V_1S_2, V_1S_1, in the both cases (Fig.7). It was observed from drying studies that whole ginger rhizome dried under STD retained maximum essential oil. Open Sun dried ginger had lesser oleoresin content as compared to Solar Tunnel dried ginger in both varieties (Fig.6).The pungency constituents in the oleoresin of ginger like total gingerols Bilal *et al.* (2021) [2] and shogoals also showed a decreasing trend Visvanathan (2019) [3] and *Thippanna et.al* (2019) [8]. There was a significant difference between each samples in both varieties and both STD and OD.This variation on the basis of drying technique used was found to be statistically significant (P≤0.0001) Thippanna and Tiwari (2015) [7].

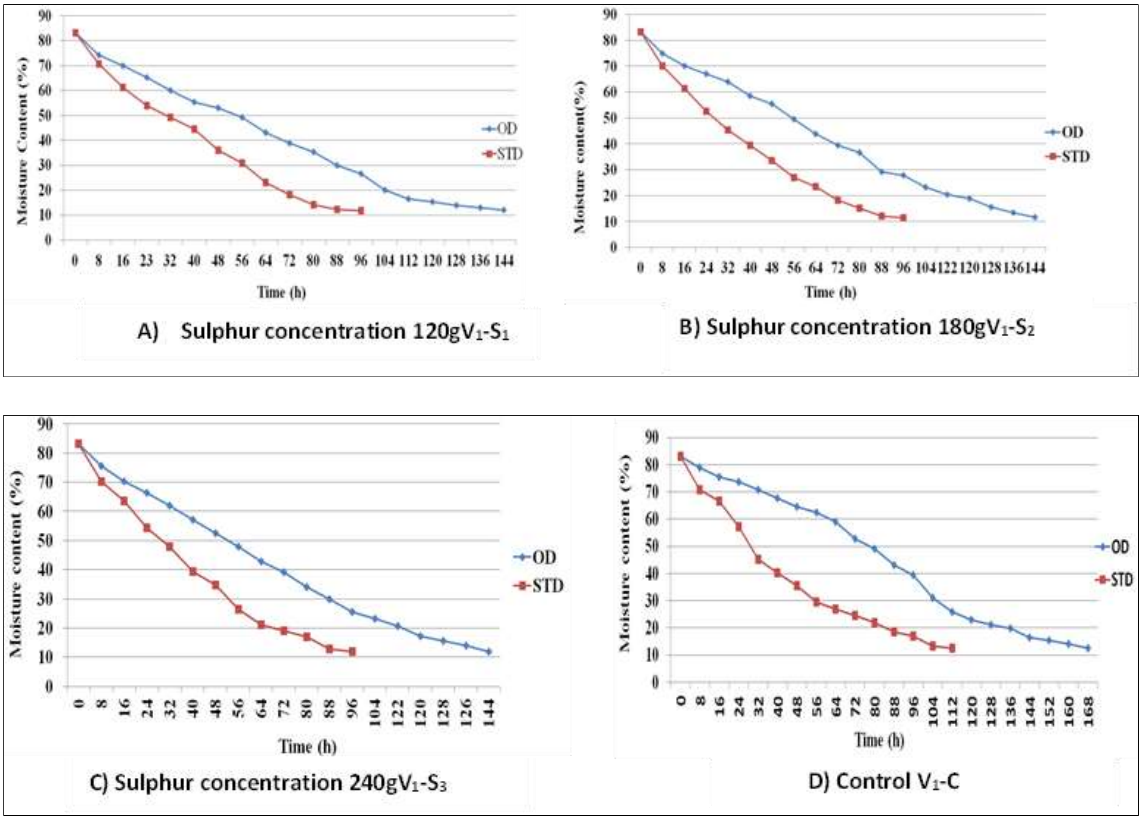

Fig 6: Variation ofMoisture content of Ginger varRio-de-janeiro (V1)

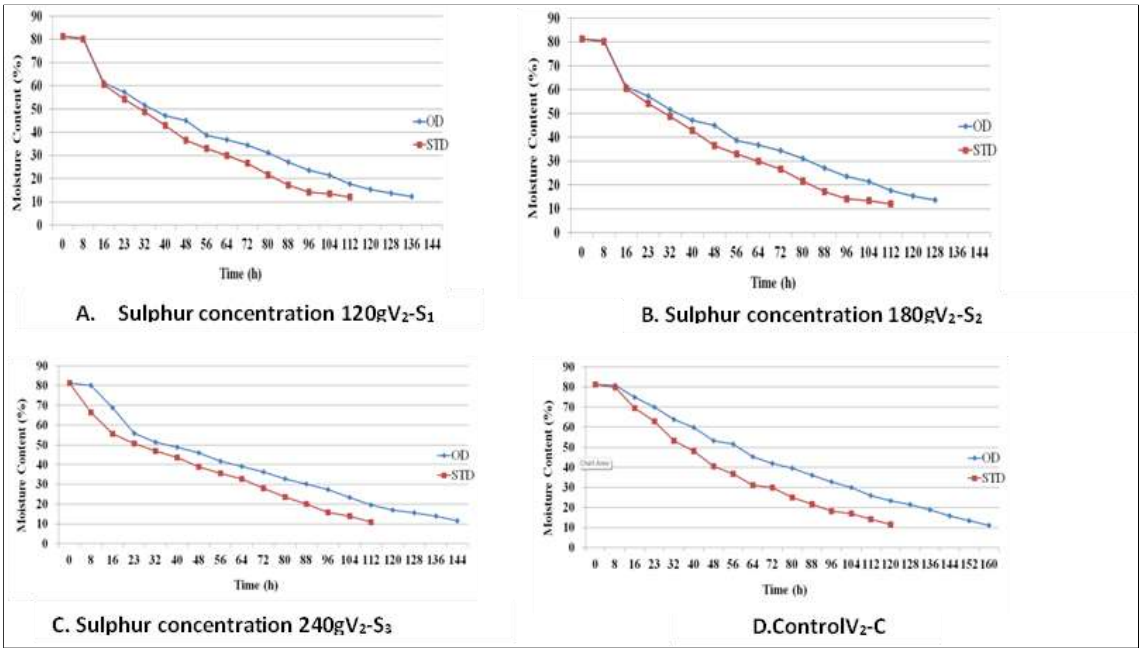

Fig 7: Variation ofMoisture content of Ginger varHimachal (V2)

Microbiology analysis

According to pooled result there were no bacterial colonies; yeast, mold and any other micro-organisms were found to appear in the performed experiments.This was due to the antimicrobial property present in the ginger which resists the growth of micro-organisms as well as low water activity of dry powder samples of both the varieties. The ginger is rich in its antimicrobial property which stops the activity of micro-organisms.

Fig 11: Microbial analyses of Rio-de-janeiro& Himachal

Colour analysis

The colour values were obtained by the grating spectrophotometer. The determination of colour values was done for two varieties and eight samples for each variety including control sample in-terms of L, a, b values. From the obtained result, the lighter colour was observed in STD-S_3 sample followed by STD-S_2, STD-S_1 and STD-control sample than S_3, S_2, S_1 and control sample in OD in Ginger var*Rio-de-janeiro*. The same result was found in Ginger var *Himachal* that is STD-S_3 resulted in lighter colour followed by STD-S_2, STD-S_1 and STD-control as compared to S_3, S_2, S_1 and control sample in open sun drying**.**This was due to the Sulphur fumigation, as sulphur has the property to bleach the sample, the S_3 sample was treated with higher concentration of sulphur than S_2 and S_1 in both the varieties and both the drying methods. This variation on the basis of drying technique used was found to be statistically significant ($p \leq 0.0001$)**.**

Table 4: Colour analysis of Ginger var*Rio-de-janeiro*(V_1)

	OD				STD			
	S_1	S_2	S_3	Control	S_1	S_2	S_3	Control
L*	72.39±0.06	75.78±1.87	79.29±1.73	70.80±1.10	74.50±1.53	77.90±0.01	80.99±0.84	71.38±0.37
a*	6.21±0.05	6.38±0.29	6.64±0.04	6.03±1.16	6.59±0.32	6.69±0.01	7.73±0.04	7.63±0.04
b*	18.98±0.15	20.41±0.31	27.03±0.46	15.40±1.27	22.84±1.14	24.50±0.99	27.55±0.15	20.66±0.03

The test values along the same row carrying different superscripts are significantly different ($p<0.05$) according to One-way ANOVA followed by Post-hoc Tukey's multiple comparison test.

Table 5: Colour analysis of Ginger var*Himachal* (V_2)

	OD				STD			
	S_1	S_2	S_3	Control	S_1	S_2	S_3	Control
L*	63.14±2.90	68.63±2.52	72.19±3.72	61.96±2.17	65.83±6.42	70.94±9.90	77.98±3.54	65.48±3.16
a*	5.03±1.75	6.33±1.84	6.6±1.26	4.91±1.68	5.25±0.21	6.69±2.59	7.24±0.71	5.14±1.12
b*	18.66±4.61	20.94±4.22	24.89±6.11	17.03±3.84	19.99±0.83	22.56±2.91	28.44±5.18	18.56±2.07

The test values along the same row carrying different superscripts are significantly different ($p<0.05$) according to One-way ANOVA followed by Post-hoc Tukey's multiple comparison test. All values are Mean ± SD of three replicates (n=3)

Conclusion

The physico-chemical parameters of solar tunnel drier were good as for open sun drier. The maintenance and operation cost of Solar tunnel drier was less as compared to open sun drier and also the drying operation can be done in large scale. The drying of ginger under open sun drying took 17-18 days (11-12%), but the quick drying was observed in solar tunnel drying that is 11-12 days (11-12%) for variety *Rio-de-janeiro*, where as in case of (*Himachal*) the same result was seen. The retention of oleoresin content was significantly higher in solar tunnel dried ginger as compared to open sun dried ginger in both of the variety. There is no significant difference in color of the dried ginger performed in both driers but visually solar tunnel dried ginger was whiter than open sun dried ginger. The microbial analysis performed for both varieties resulted in zero microbial loads in open drying and solar tunnel drier.

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